Integration of Spent Coffee Grounds with 3D Printing Resin

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The Grand Challenge

Climate change and the overconsumption of plastics are threats to the environment and future generations. Every year, roughly 250,000 tons of wet waste coffee grounds are thrown into landfills, where they decompose and release harmful methane into the atmosphere–further amplifying the effects of climate change(1).

With the 3D printing industry growing so rapidly, our solution reuses this coffee waste product by integrating it into plastic production. We accomplished this by integrating dehydrated spent coffee grounds (SCGs) into UV resin as a new 3D printing filament(2). Through careful experimentation, research, and testing, our team has discovered suitable ratios of SCGs to UV resin that will maximize structural integrity and durability. To test the viability of our products, we utilized an INSTRON machine which gathered data to help us analyze the tensile strength of our prints(3).

Methods

Dehydrated SCGs were obtained from the Food Science Laboratory. Particle size distribution: 150 - 300 µm.

In the case SCGs were not dehydrated, they were set in an oven (60 °C) until a constant mass was obtained.

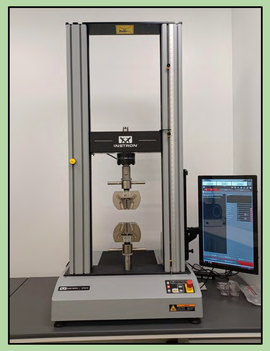
SCGs were integrated into Prusa Tough Transparent, a 3D printing resin, at varying concentrations (0, 0.5, 1, 1.5, 2 and 3 percent by weight).

$$Total\ mass\ x\left(\frac{wanted\ SCGs\ percent}{100}\right) = needed\ SCGs\ mass$$

$$Total\ mass - needed\ SCGs\ mass = Resin\ mass$$

The prepared mixture was utilized to print in the ASTM D638 dogbone shape using the PRUSA resin printer and then cured.

The print's dimensions were recorded after sanding and tested under INSTRON tensile testing machine.



Literature Cited

1. Rohr, N., Fischer, J. Effect of aging and curing mode on the compressive and indirect tensile strength of resin composite cements. Head Face Med 13, 22 (2017).
2. Tellers, J., Willems, P., Tjeerdsma, B., Sbirrazzuoli, N. and Guigo, N. (2021), Spent Coffee Grounds as Property Enhancing Filler in a Wholly Bio-Based Epoxy Resin. Macromol. Mater. Eng., 306:
3. Alshamrani, A. A., Raju, R., & Ellakwa, A. (2022). Effect of Printing Layer Thickness and Postprinting Conditions on the Flexural Strength and Hardness of a 3D-Printed Resin. BioMed Research International, 1–9

Results

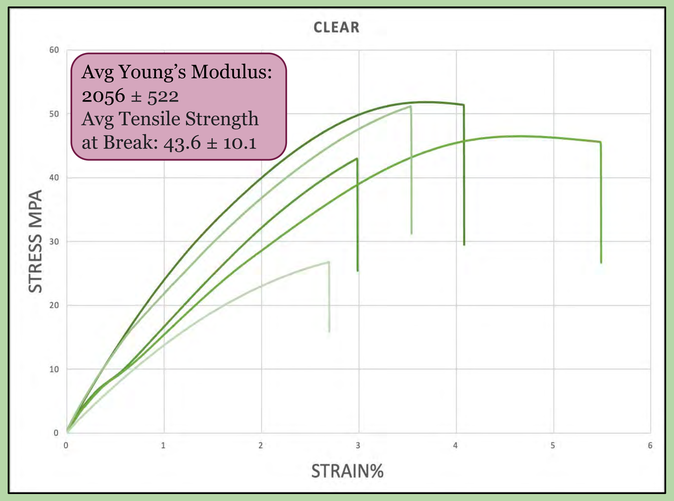


Figure 1a: Tensile strength of 0% by weight SCGs to resin.

Figure 1b: Breakage points of the clear dog bones

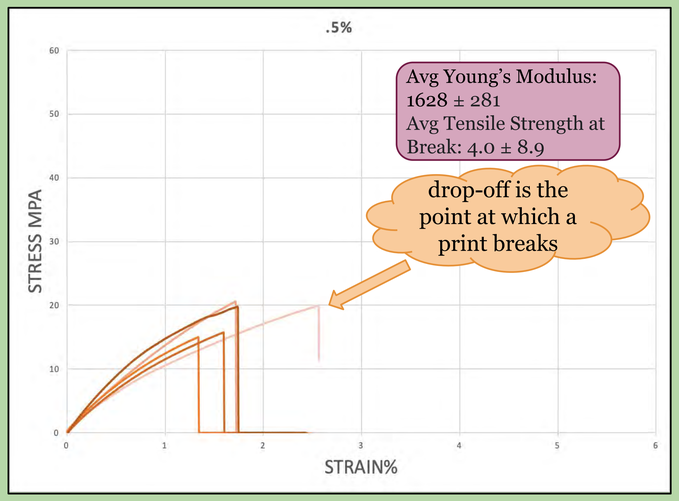


Figure 2a: Tensile strength of 0.5 % by weight SCGs to resin.

Figure 2b: Breakage points of the 0.5% coffee dog bones

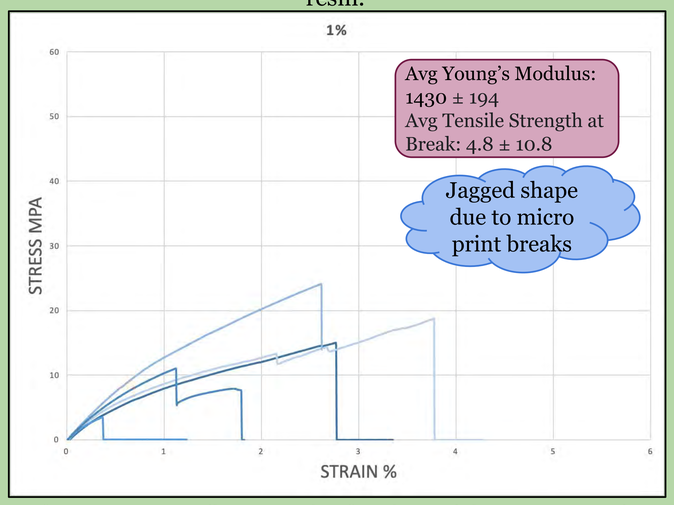


Figure 3a: Tensile strength of 1% by weight SCGs to resin.

Figure 3b: Breakage points of the 1% coffee dog bones

Conclusions

- The tensile strength data shows that any composite resin (resin and SCGs mix) is significantly more brittle than resin alone
- As the concentration of coffee in the resin increased, so did the likelihood of printer failure
- The prints containing coffee grounds were all moderately inconsistent in size
- Printing with the mixture did not damage the resin printer but it made the cleaning process more difficult.
- The coffee grounds were insoluble in the resin.
- Printing the composite was often unsuccessful because the layers would peel off of the plate before the printer finished
- Coffee ground particles in the prints were never evenly distributed.

Next Steps

- Testing whether dehydration, oil extraction or chemical treatment of the coffee grounds improves our 3D print results
  - Polarity of resin and coffee grounds
- Testing different particle sizes, and understanding which would be optimal for particle suspension in the resin
- Using a commercially available composite printer rather than a regular resin printer
  - Longer exposure times
- Experimenting with different densities of coffee grounds

Acknowledgements

Team Contributions:

- Viola: Printing dogbones, data analysis
- Ryley: Prepare printing stations, cure resin and SCGs prints
- Jocelyn: Obtain and dehydrate SCGs, assist in testing dogbones
- Michelle: Introduction, assist in printing, tensile strength and material sciences research.

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